Title:	The Predicted Pressure-Time History of the Small Experiment Confinement Vessel (SECV) Incorporated Into the Proton Radiography Beam Line
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	Los Alamos National Laboratory **Weapon Systems Engineering Division**

The Predicted Pressure-Time History of the Small Experiment Confinement Vessel (SECV) Incorporated Into the Proton Radiography Beam Line

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☐ Applies to all W-DO Projects **Status:** ☒ New ☐ Major Revision ☐ Minor Revision ☐ Reviewed, No Change	

This document deemed Unclassified by
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(DC)

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1.0 INTRODUCTION

The Small Experiment Confinement Vessel (SECV) was originally designed to be used at the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility, and is a simple, cylindrical wall vessel that requires no radiographic windows. The wall of the vessel is of a thickness dimension, 0.6 inch nominal, and the DARHT radiographic dose is high enough that the confined experiment can be imaged by radiography through the vessel wall. The current experiment intent is to use the SECV in the proton radiography, pRad, experiment area by integrating the vessel weldment into the pRad beam line configuration. Figure 1 depicts the new configuration of the SECV in the pRad beam line.

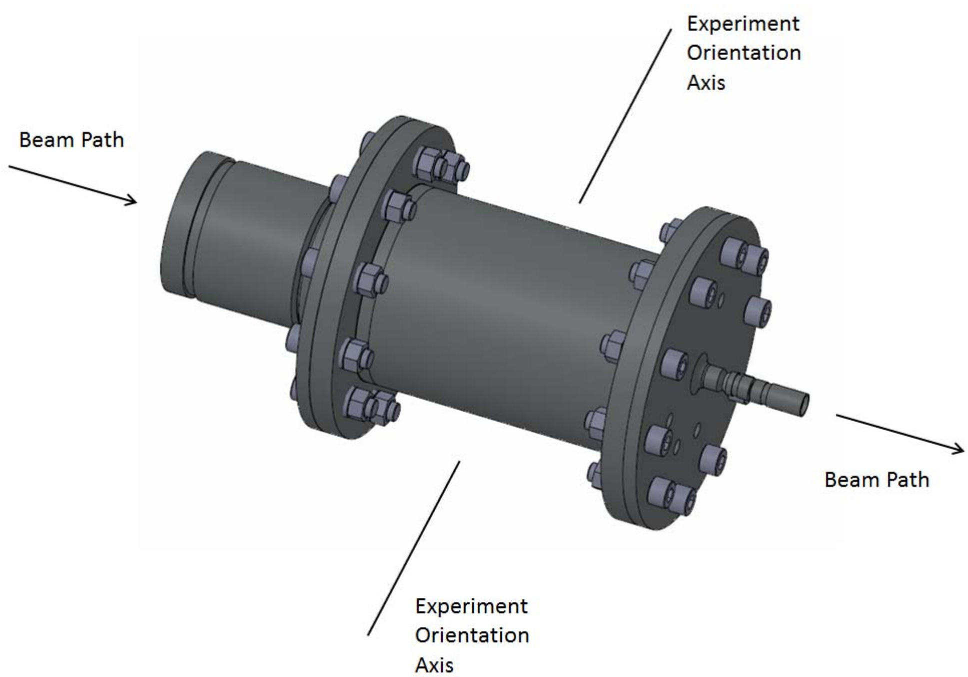

Figure 1, SECV Orientation in the pRad Beam Line

The SECV is nominally 10.75 inch in outside diameter, 18 inch in internal height, and weighs approximately 450 pounds when fully assembled. The design High Explosive (HE) mass detonation load for the SECV is 30 grams of plastic bonded explosive (PBX) 9501. Los Alamos National Laboratory (LANL) drawing 34Y1762704 shows the details of the SECV assembly.

The vessel cylindrical body is made of pipe steel per the standard American Petroleum Institute (API) 5L Grade X65Q PSL 2. Grade X65Q PSL 2 pipe steel comes with the requirement to meet a minimal fracture toughness strength level as determined through Charpy V-notch impact testing. This makes the pipe steel a good candidate material for moderate impulsively loaded vessels. The vessel end nozzles, which are welded to the cylindrical body, are made of HSLA-100 steel. One inch diameter bolts per the standard ASTM A574 are used to fasten the end covers to the main vessel body nozzles.

The SECV original structural design as a free standing firing vessel has been done per the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Division 3, Alternative Rules for Construction of High Pressure Vessels, Code Case 2564-1 for impulsively loaded vessels. The SECV now being placed in a different orientation, and having the ends restrained will be evaluated by others for its structural compliance to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 3, Alternative Rules for Construction of High Pressure Vessels, Code Case 2564 for impulsively loaded vessels.

The scope of the work reported here is to obtain a new pressure-time history for the vessel walls due to the new orientation of the experiment assembly relative to the centerline of the vessel.

2.0 EXPERIMENT CONFIGURATION

The most extreme experiment configuration relative to the impulsive loading of the vessel is to have the centerline of the cylindrical shaped high explosive lens orthogonal to the centerline of the vessel, as depicted in Figure 2.

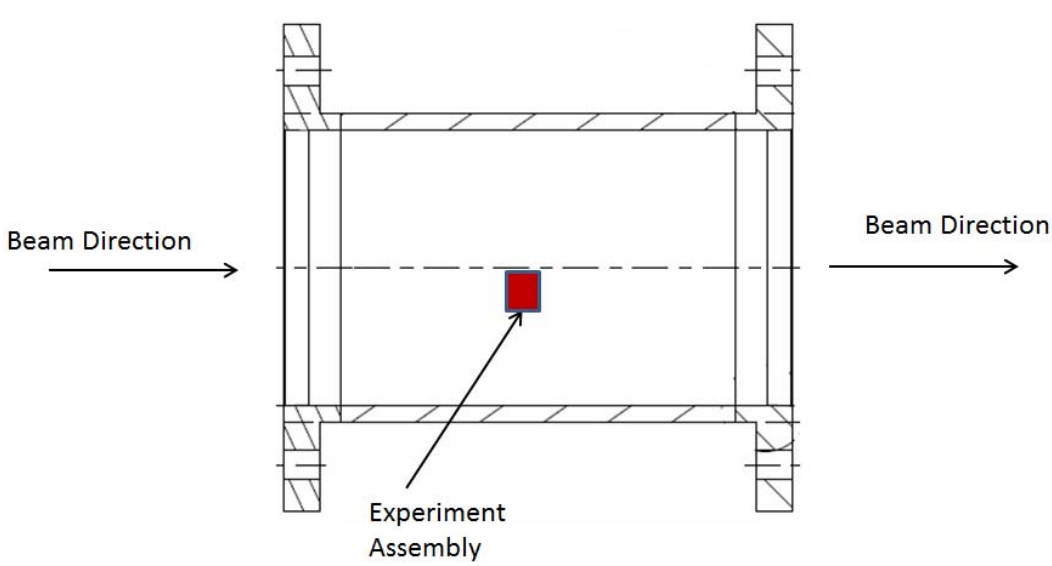

Figure 2, Experiment Assembly Orientation in SECV

The design load of the SECV is 30 grams of PBX9501, or 34 grams of TNT. For this analysis to predict the pressure-time history of the pRad configuration that charge mass size has been increased by 20%, to 41 grams of TNT as a safety factor.

Fragment impacts on the vessel wall are not seen as an issue for the SECV in the pRad configuration. The assumption is made that shields will be employed where needed to protect the vessel wall from fragment impacts.

3.0 HYDRODYNAMIC MODEL DESCRIPTION

The pressure-time history of the experiment detonation has been predicted using a three dimensional model of the SECV in the pRad configuration. The experiment assembly being oriented normal to, and off-set from the vessel centerline requires a three dimensional model in order to acquire a prediction of the asymmetric dynamic pressure loading of the vessel interior.

Figure 3 provides a view of the three dimensional hydrodynamic model, which is a 180 degree symmetric model that represents the entire vessel pressure loading via the use of a plane of symmetry extending through the vessel longitudinally. The plane of symmetry for the model cuts completely through the vessel configuration creating a half sector of the total vessel and charge configuration.

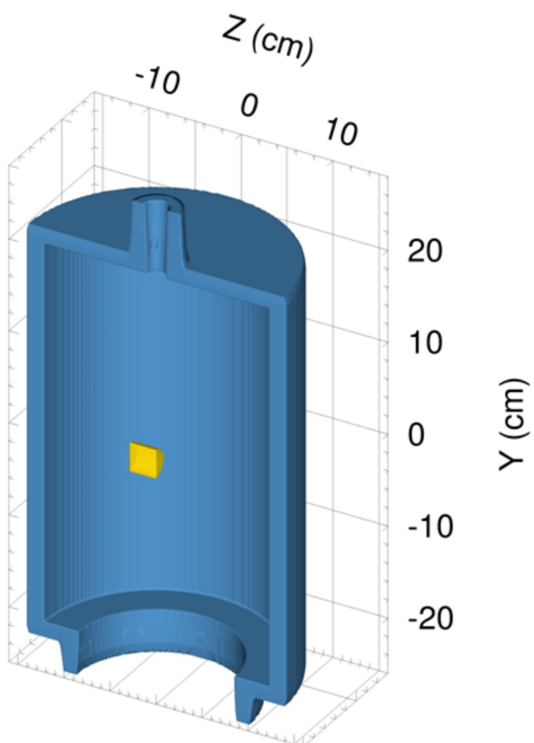

Figure 3, The Three Dimensional Hydrodynamic Model of the SECV in the pRad Configuration

The hydrodynamic model is created and analyzed using the computer hydrodynamic modeling code CTH, version 10.3. CTH is produced and maintained by Sandia National Laboratory.

The starting pressure inside of the vessel is modeled as approximately 1/100 of an atmosphere, or 0.147 psia. This accounts for the fact that the vessel interior, and the pRad beam line are evacuated to a vacuum level of approximately 10 Torr.

A total of twenty-nine pressure zones are mapped onto the vessel wall interior, and the end flange interior walls. Figures 4 through 7 show the position and size of each interior zone.

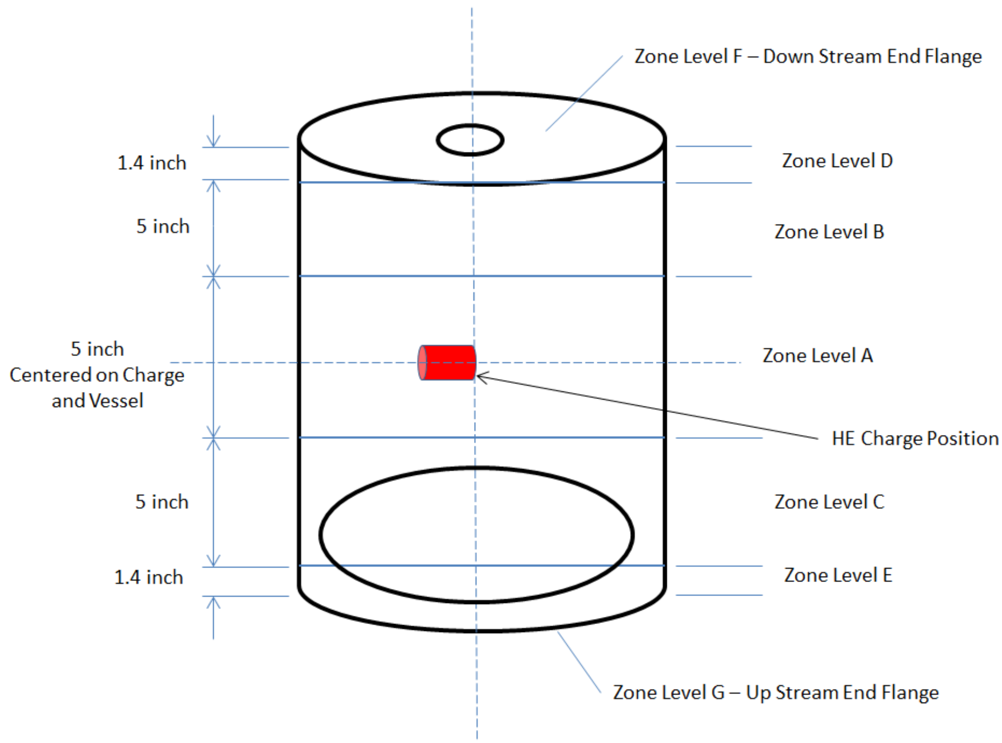

Figure 4, The Vertical View of the Pressure Zones for the SECV Hydrodynamic Model

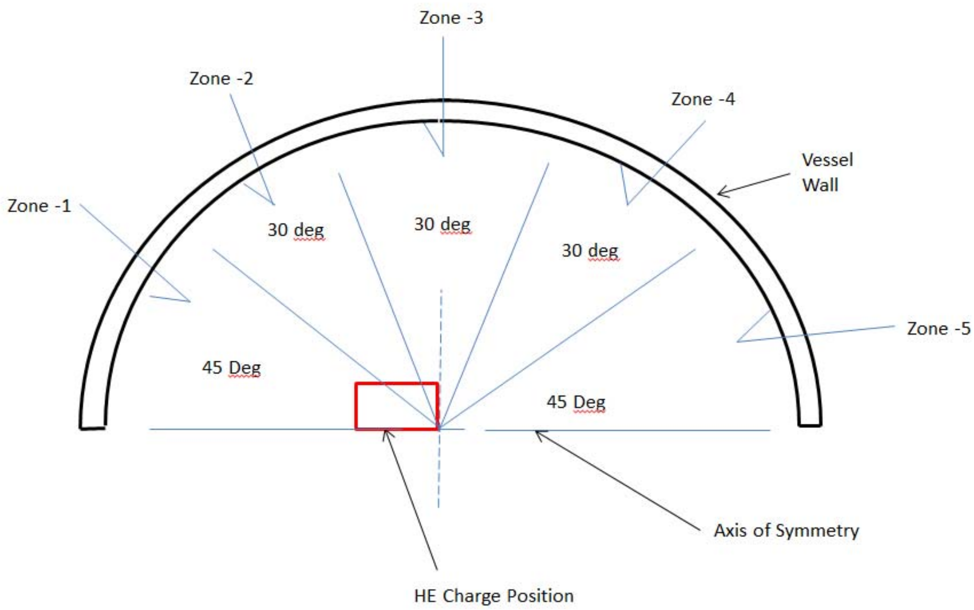

Figure 5, The Azimuthal View of the Vessel Wall Pressure Zones for the SECV Hydrodynamic Model, For Levels A through E

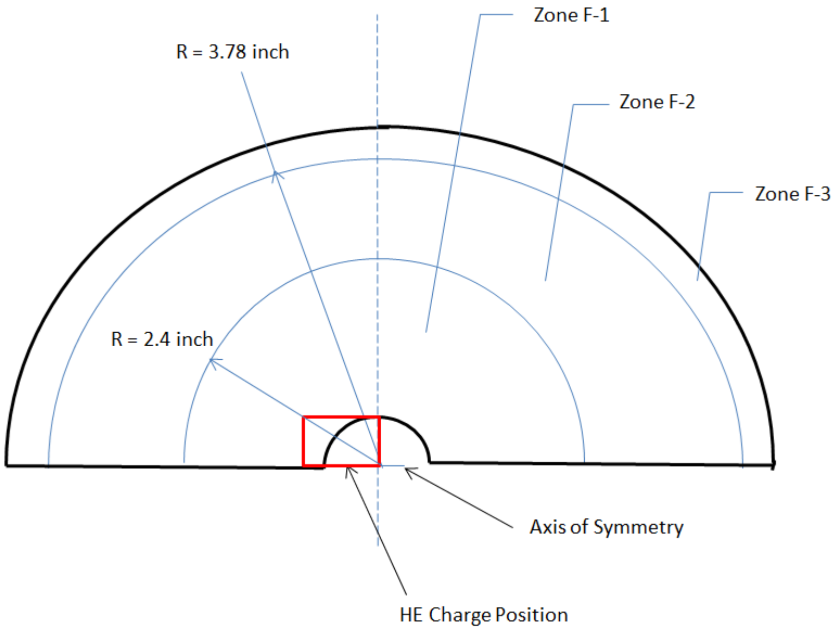

Figure 6, The View of the Down Stream End Flange Pressure Zones for the SECV Hydrodynamic Model

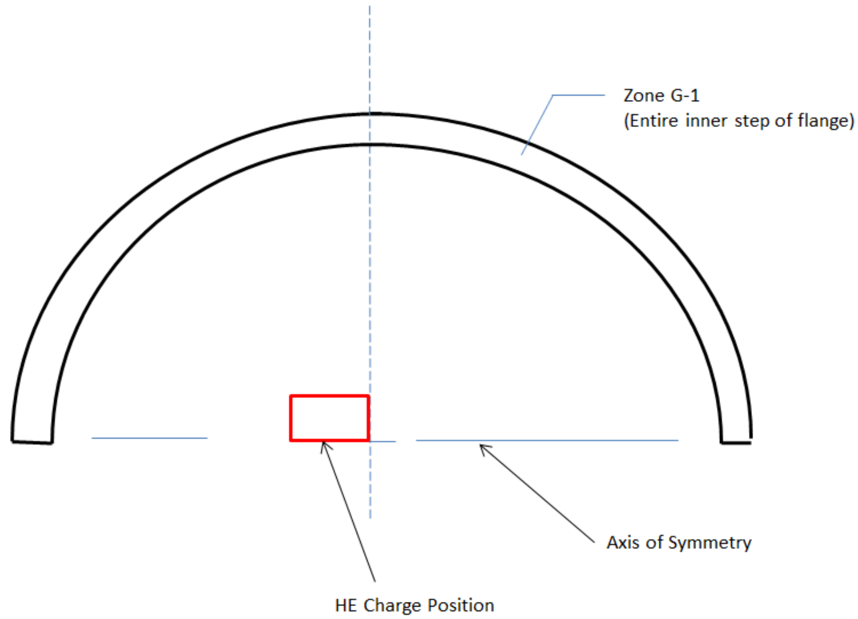

Figure 7, The View of the Up Stream End Flange Pressure Zone for the SECV Hydrodynamic Model

4.0 RESULTS SUMMARY

Figure 8 shows the predicted development of the blast front up to the time of first impact with the vessel wall, which is approximately 25 microseconds. The asymmetric nature of the blast development within the geometry of the vessel that is due to the charge off-set position can be seen.

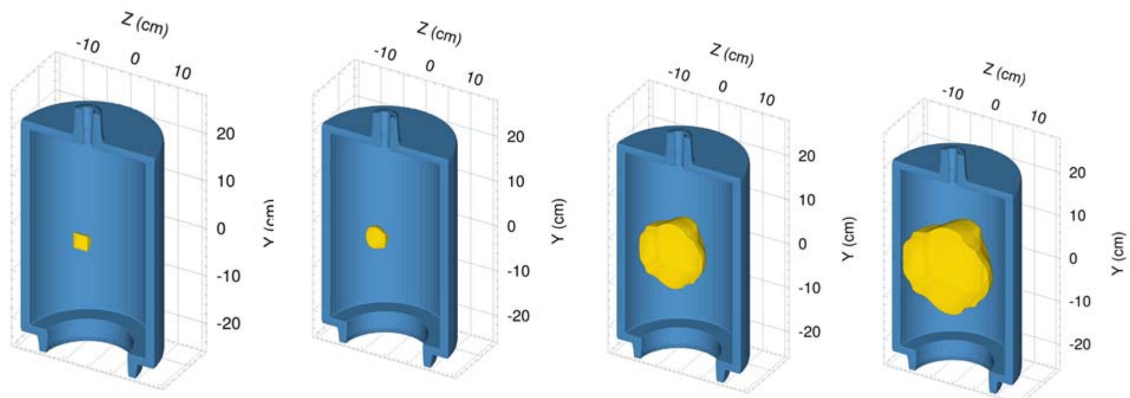

Figure 8, The Blast Front Development Predicted for the SECV in the pRad Configuration, to Time ~ 15 microseconds

Figure 9 shows the predicted temporal pressure profile for the highest loaded zones, which are the vessel mid height interior zones that are directly aligned with the high explosive charge.

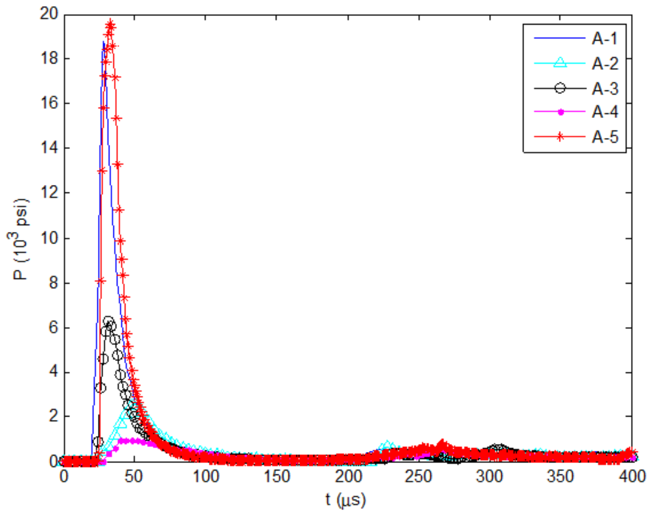

Figure 9, The Predicted Pressure-Time History of the Interior Zones A-1 through A-5 of the SECV, Pressure in psia, Time in microseconds

The predicted results for the pressure-time history of the detonation event are plotted for selected areas of the vessel in Figures 10 through 14.

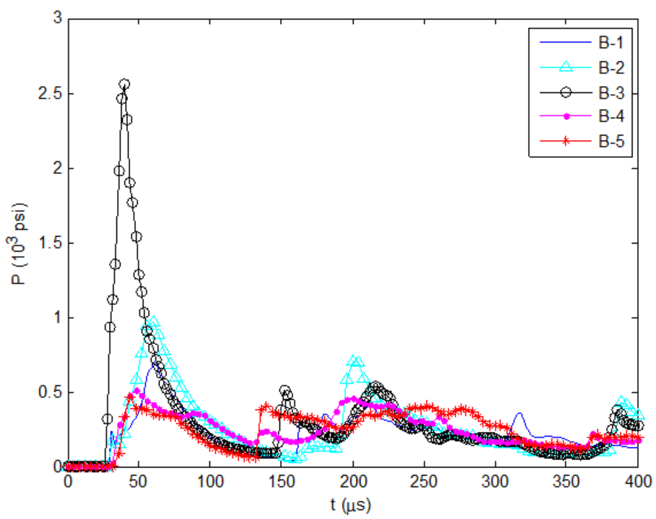

Figure 10, The Predicted Pressure-Time History in Zones B-1 through B-5 of the SECV, Pressure in psia, Time in microseconds

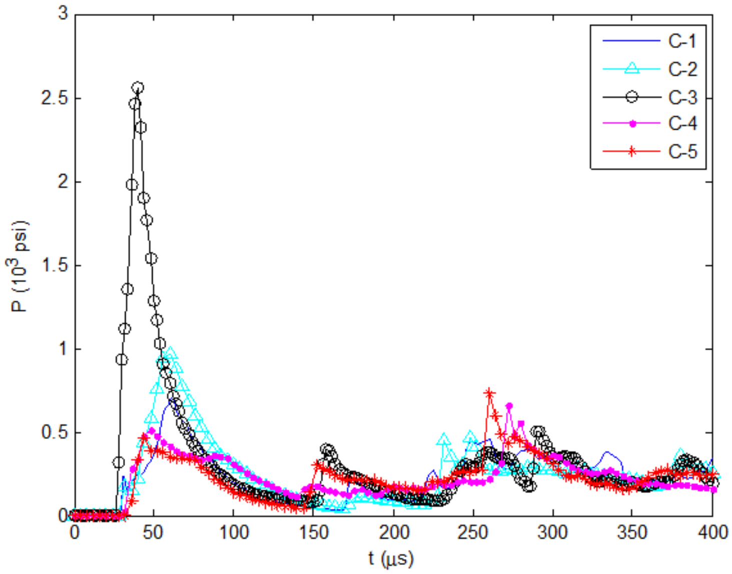

Figure 11, The Predicted Pressure-Time History in Zones C-1 through C-5 of the SECV, Pressure in psia, Time in microseconds

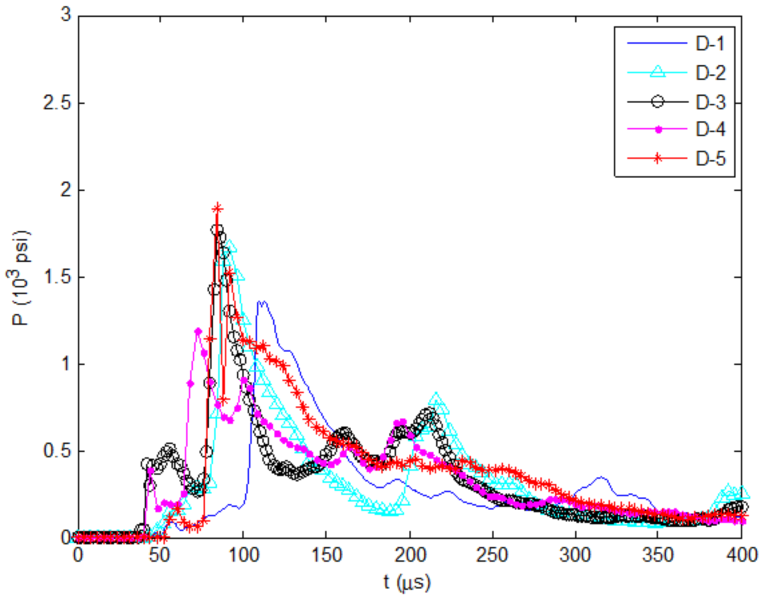

Figure 12, The Predicted Pressure-Time History in Zones D-1 through D-5 of the SECV, Pressure in psia, Time in microseconds

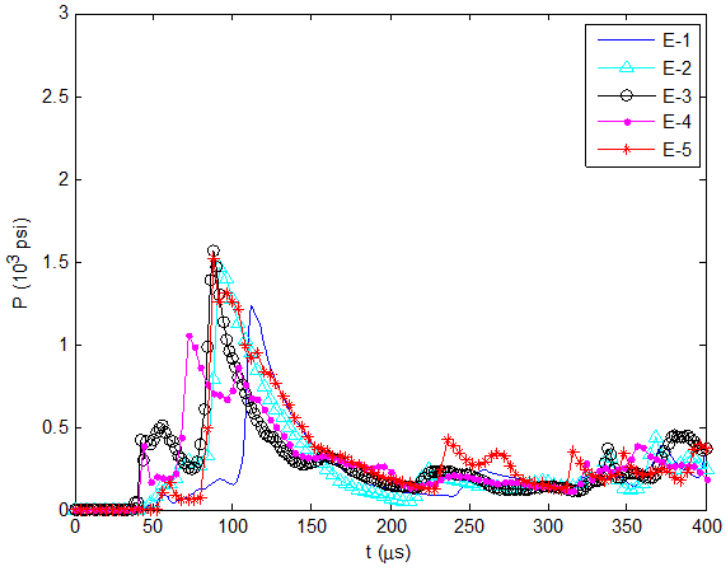

Figure 13, The Predicted Pressure-Time History in Zones E-1 through E-5 of the SECV, Pressure in psia, Time in microseconds

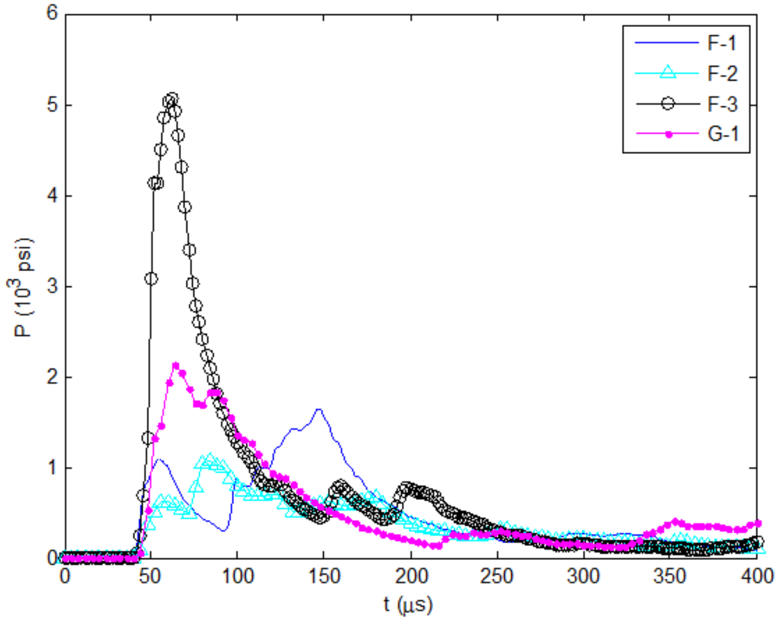

Figure 14, The Predicted Pressure-Time History in Zones F-1 through F-3 and G1 of the SECV, Pressure in psia, Time in microseconds